



(12) UK Patent (19) GB (11) 2 382 367 (13) B

(45) Date of publication: 22.09.2004

(54) Title of the invention: Coupling an expandable liner to a wellbore casing

(51) Int Cl⁷: E21B 23/00 23/08 29/00 43/10

(21) Application No: 0300085.8

(22) Date of Filing: 27.07.2001

(30) Priority Data:
(31) 60221645 (32) 28.07.2000 (33) US

(60) Parent of Application No(s)
0416834.0 under Section 15(4) of the Patents Act 1977

(86) International Application Data:
PCT/US2001/023815 En 27.07.2001

(87) International Publication Data:
WO2002/010550 En 07.02.2002

(43) Date A Publication: 28.05.2003

(52) UK CL (Edition W):
E1F FLA

(56) Documents Cited:
US 6085838 A US 6012522 A
US 5494106 A US 3353599 A
US 2812025 A US 2796134 A

(58) Field of Search:
As for published application 2382367 A viz:
Other: U.S. : 166/207, 277, 381, 383;
Online: DERWENT, JPO, EPO
updated as appropriate

(72) Inventor(s):
Robert Lance Cook
Lev Ring

(73) Proprietor(s):
Enventure Global Technology
(Incorporated in USA - Delaware)
16200 A Park Row, Houston, Texas 77084,
United States of America

(74) Agent and/or Address for Service:
Haseltine Lake & Co
Redcliff Quay, 120 Redcliff Street,
BRISTOL, BS1 6HU, United Kingdom

2382367

1/7

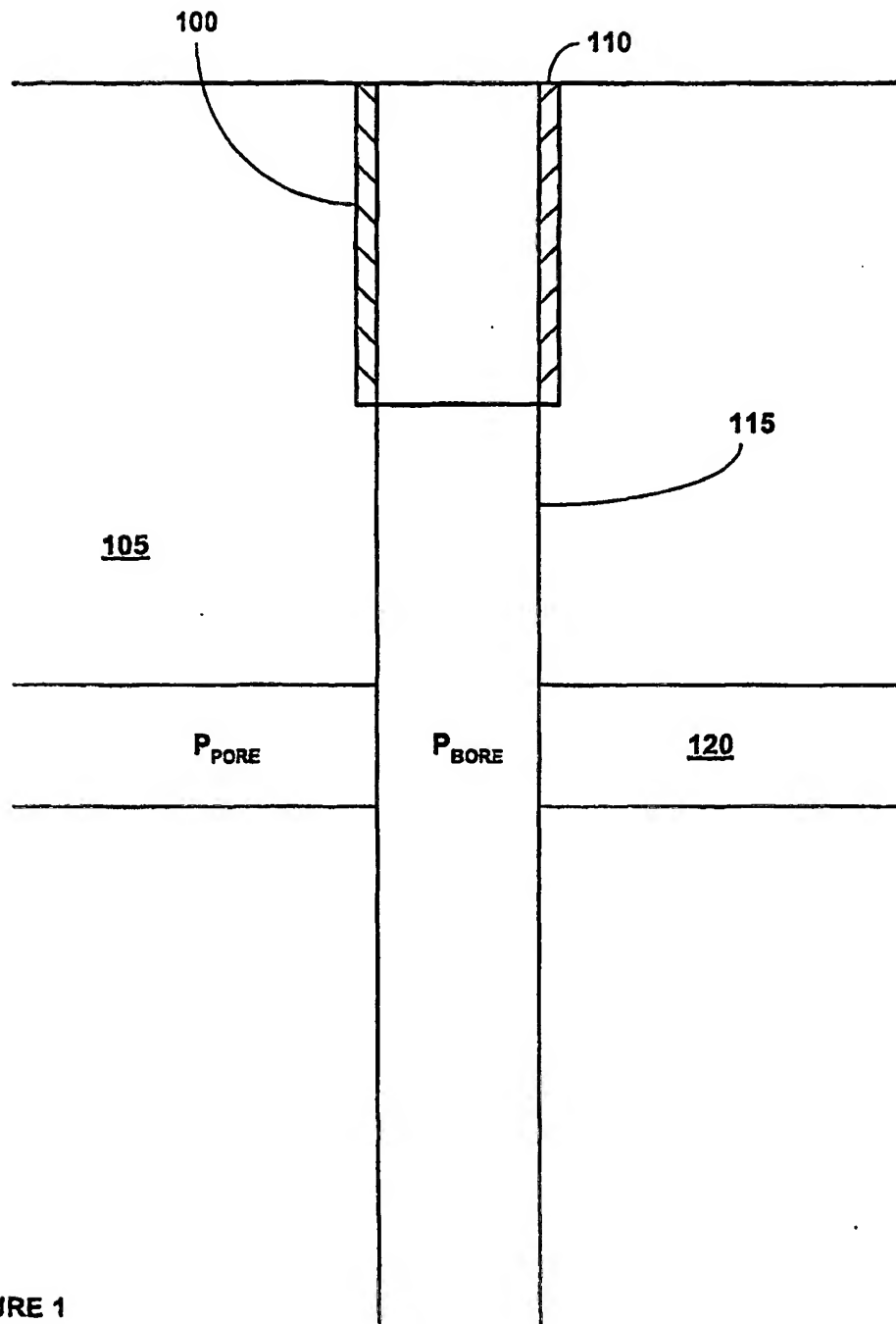


FIGURE 1

This diagram shows a cross-sectional view of a wellbore completion system. A central mandrel (200) is positioned within a wellbore (100). The mandrel features a central channel (240) and a tapered section (245) at the bottom. A sleeve (205) is installed around the mandrel, with a seal (210) at the top. The sleeve is composed of multiple layers (260a through 260h) and a base layer (265). A filter cake (255) is formed on the inner surface of the sleeve. The wellbore is divided into zones (105, 120, 115) by horizontal barriers (110, 125). A bottom hole assembly (220, 230, 235) is located at the bottom of the wellbore.

FIGURE 2

FIGURE 3

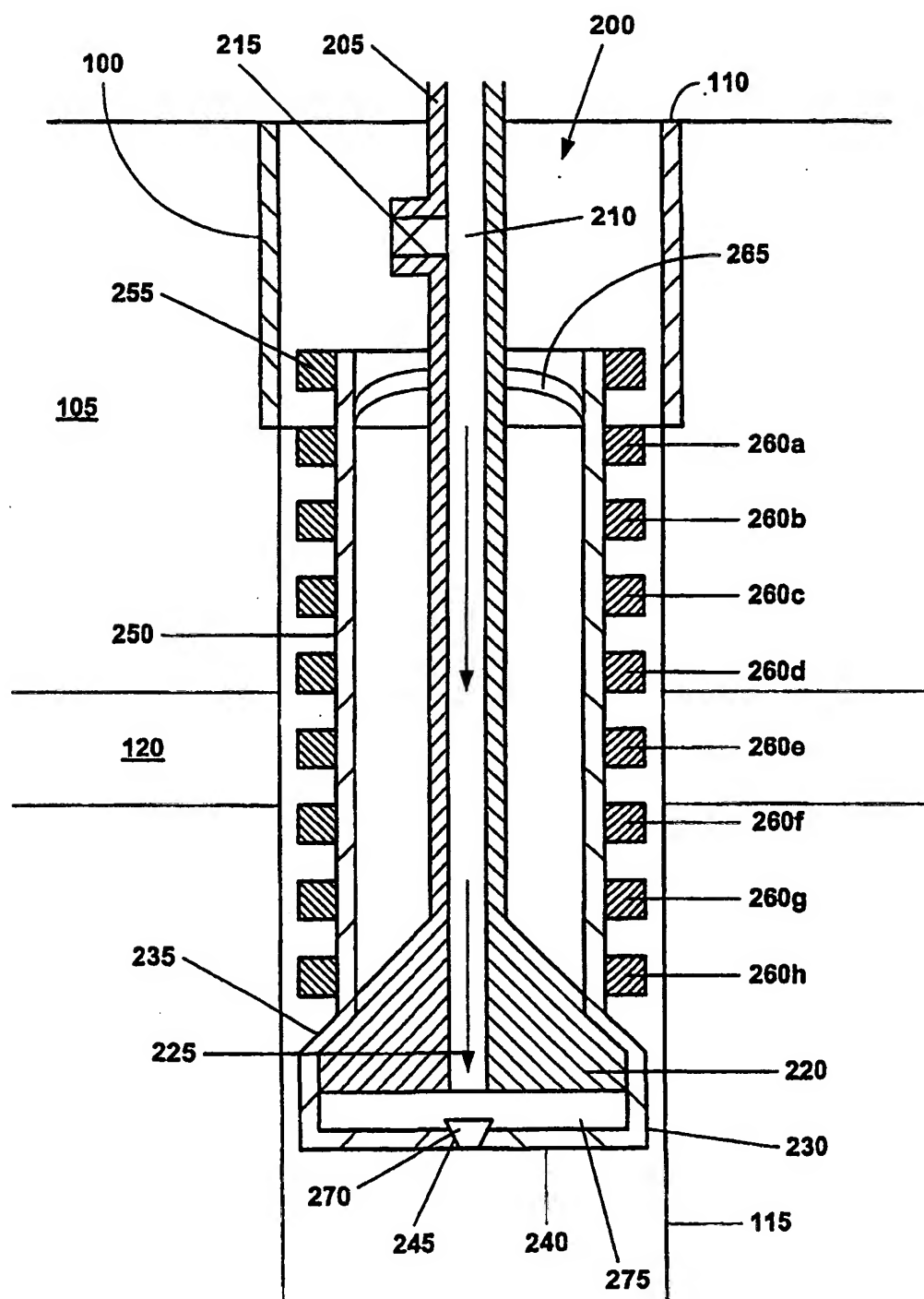


FIGURE 4

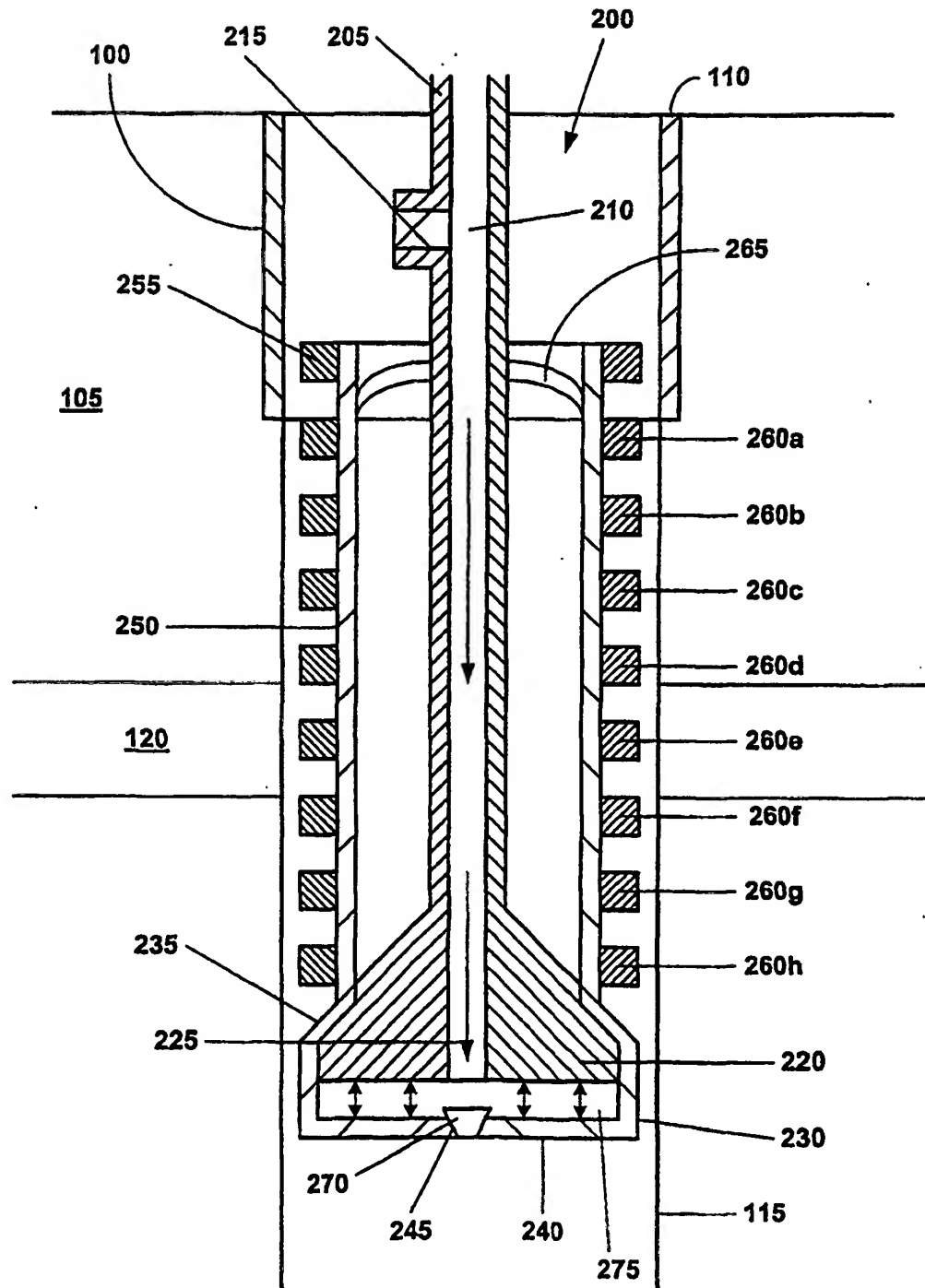


FIGURE 5

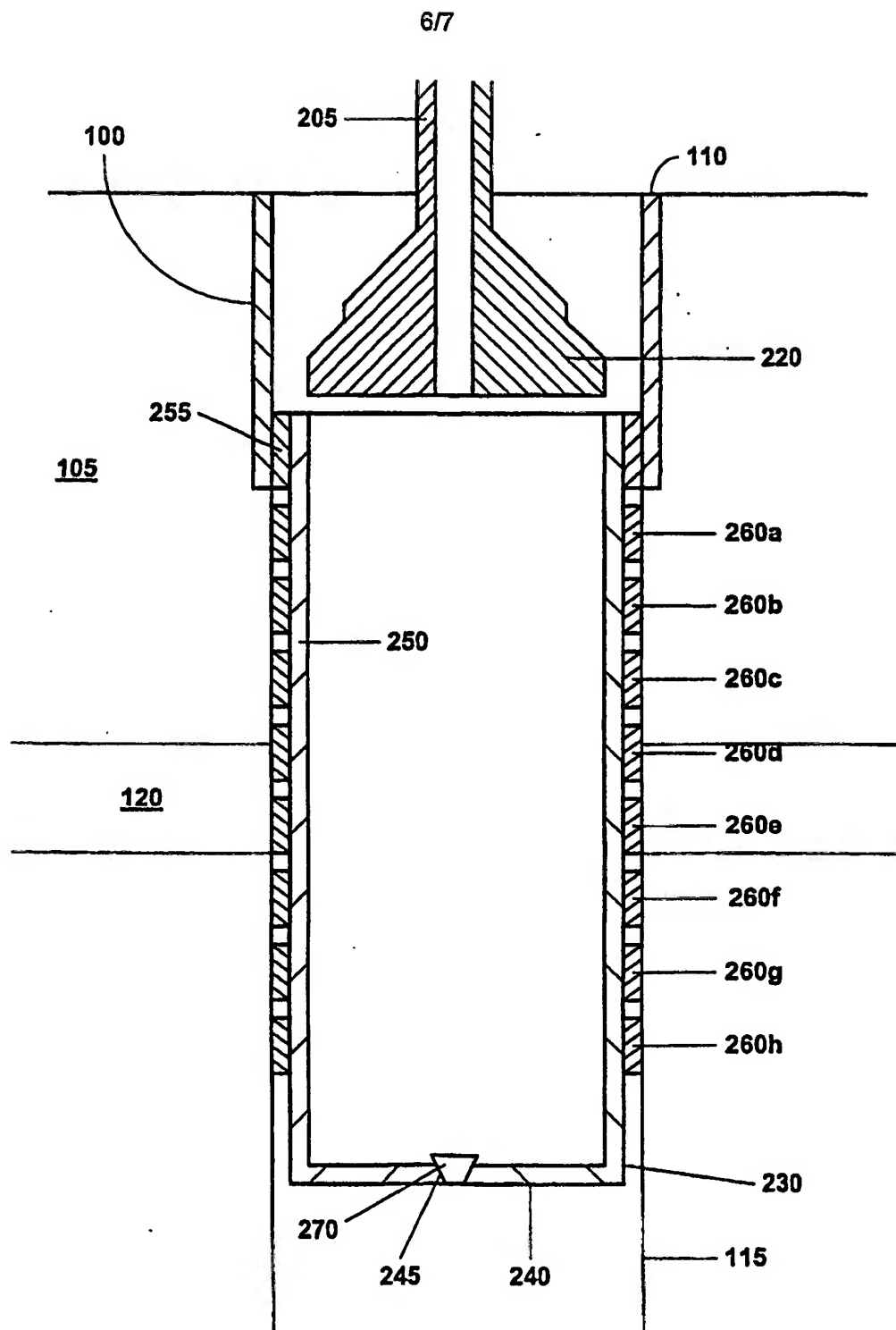


FIGURE 6

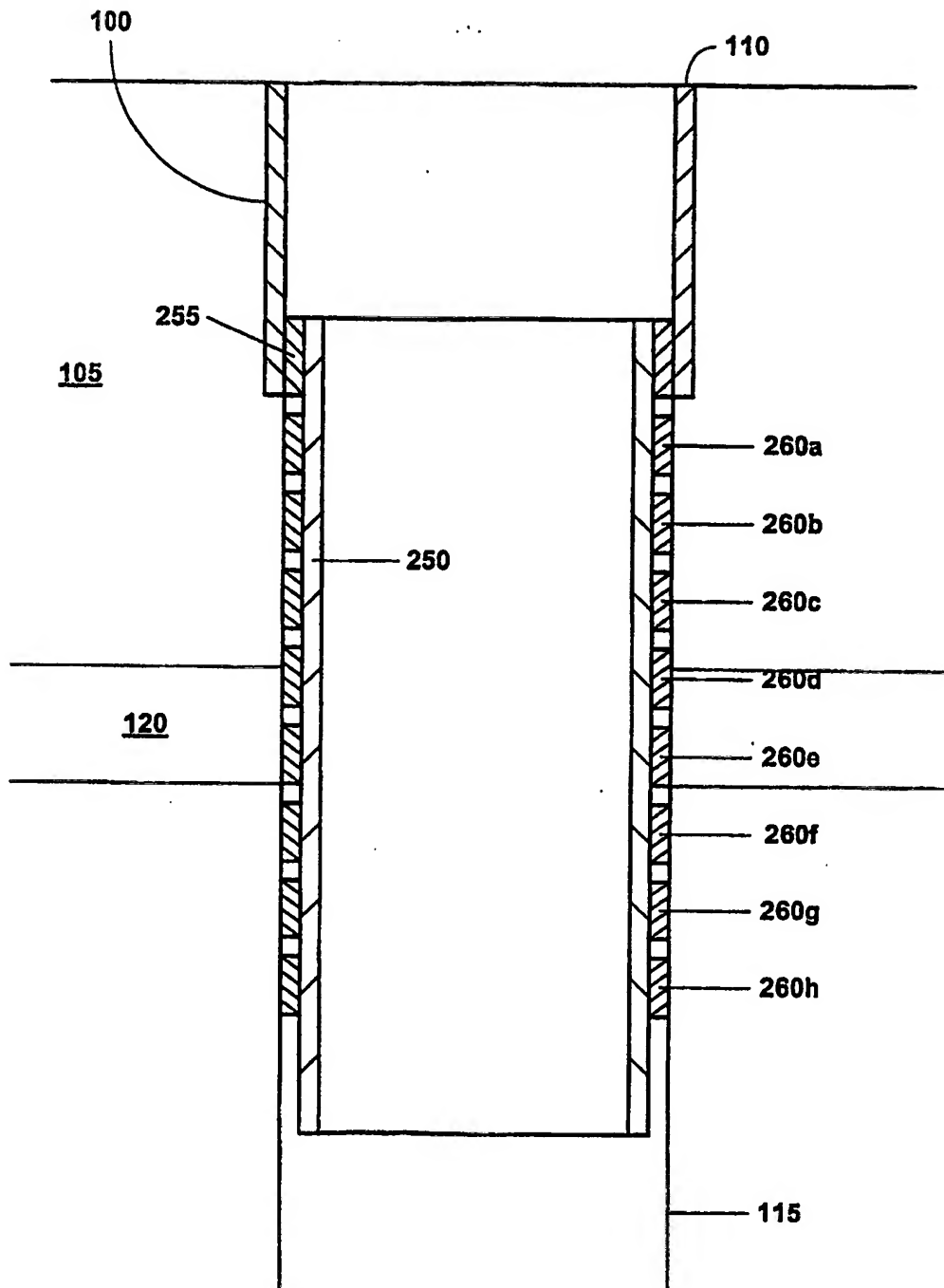


FIGURE 7

2382367

COUPLING AN EXPANDABLE LINER TO A WELLBORE CASING

This invention relates to coupling an expandable liner to a wellbore casing.

Conventionally, when a wellbore is created, a number of casings are
5 installed in the borehole to prevent collapse of the borehole wall and to prevent
undesired outflow of drilling fluid into the formation or inflow of fluid from the
formation into the borehole. The borehole is drilled in intervals whereby a casing
which is to be installed in a lower borehole interval is lowered through a
previously installed casing of an upper borehole interval. As a consequence of
10 this procedure the casing of the lower interval is of smaller diameter than the
casing of the upper interval. Thus, the casings are in a nested arrangement with
casing diameters decreasing in downward direction. Cement annuli are provided
between the outer surfaces of the casings and the borehole wall to seal the casings
from the borehole wall. As a consequence of this nested arrangement a relatively
15 large borehole diameter is required at the upper part of the wellbore. Such a large
borehole diameter involves increased costs due to heavy casing handling
equipment, large drill bits and increased volumes of drilling fluid and drill
cuttings. Moreover, increased drilling rig time is involved due to required cement
pumping, cement hardening, required equipment changes due to large variations in
20 hole diameters drilled in the course of the well, and the large volume of cuttings
drilled and removed.

The present invention is directed to overcoming one or more of the
limitations of the existing procedures for forming wellbores and wellheads.

Summary of the Invention

25 According to the present invention there is provided in a wellbore that
traverses a subterranean formation and includes a cased section having a wellbore
casing and an uncased section that traverses a porous subterranean zone, wherein
the operating pressure of the wellbore is greater than the operating pressure of the
porous subterranean zone, a method of coupling a tubular liner to the wellbore
30 casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the
wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, preventing a portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

- 5 radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

 preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased
10 section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

 Preferably, the method further comprises:

 during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the
15 wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore; and

 preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased
20 section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

 Preferably, the expansion device comprises an expansion cone.

 Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

- 25 According to another aspect of the present invention there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a
30 tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

5 during the positioning of the portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore proximate the porous subterranean zone, maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing;

10 radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

15 maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing proximate the porous subterranean zone.

Preferably, the expansion device comprises an expansion cone.

20 Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

Preferably, maintaining the longitudinal centerline of the expansion device during the radial expansion comprises placing a plurality of standoffs about the solid tubular liner.

25 According to another aspect of the present invention there is provided in a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

30 means for positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

- 5 means for radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

- means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the system further comprises:

- means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore; and

- means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, the means for radially expanding the solid tubular liner comprises a means for injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

- 25 Preferably, the means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone comprises a plurality of standoffs about the solid tubular liner.

- According to a further aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a

tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

means for positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

5 means for, during the positioning of the portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore, maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing;

10 means for radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the
15 portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, the means for radially expanding the solid tubular liner
20 comprises a means for injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

Preferably, the means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the
25 wellbore casing during the radial expansion of the portion of the solid tubular liner comprises a plurality of standoffs about the solid tubular liner.

According to another aspect of the present invention, there is provided an apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the
30 wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

a tubular support member defining a first internal passage;

an expansion device coupled to the tubular support member defining a second internal passage fluidically coupled to the first internal passage;

a tubular expansion device launcher movably coupled to and mating with the expansion device;

5 a solid tubular liner coupled to an end of the tubular expansion device launcher; and

a shoe coupled to another end of the tubular expansion device launcher including a valveable passage;

means for, during a positioning of the solid tubular liner within the
10 wellbore, preventing a portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of
15 the wellbore during a radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the apparatus further comprises:

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap
20 with the wellbore casing from adhering to the porous subterranean zone of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the wellbore during the radial expansion of the portion of the solid tubular liner
25 that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, the means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the wellbore during a radial expansion of the portion of the
30 solid tubular liner comprises a plurality of standoffs about the solid tubular liner.

According to another aspect of the present invention, there is provided an apparatus for coupling a tubular liner to a wellbore casing within a wellbore that

traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

- a tubular support member defining a first internal passage;
- 5 an expansion device coupled to the tubular support member defining a second internal passage fluidically coupled to the first internal passage;
- a tubular expansion device launcher movably coupled to and mating with the expansion device;
- a tubular liner coupled to an end of the tubular expansion device launcher;
- 10 a shoe coupled to another end of the tubular expansion device launcher including a valveable passage;
- means for, during a positioning of a portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore, maintaining a longitudinal center line of the expansion device in a position that is substantially
- 15 coincident with a longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing; and
- means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the solid tubular liner during a longitudinal displacement of the expansion device
- 20 relative to the tubular liner.

Preferably, the expansion device comprises an expansion cone.

- Preferably, the means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the solid tubular liner during a longitudinal displacement of the
- 25 expansion device comprises a plurality of standoffs about the solid tubular liner.

- According to another aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than
- 30 the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing, wherein the solid tubular liner includes a resilient helical standoff coupled to the exterior surface of the solid tubular liner;

5 during the positioning of the solid tubular liner within the wellbore, the resilient helical standoff preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

 radially expanding the solid tubular liner by injecting a fluidic material into
10 the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner;

 and the resilient helical standoff preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial
15 expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

 Preferably, the expansion device comprises an expansion cone.

 Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the
20 expansion device upwards.

 According to another aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than
25 the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

 positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing, wherein the
30 solid tubular liner includes a plurality of spaced apart resilient standoffs coupled to the exterior surface of the solid tubular liner between the opposite ends of the solid tubular liner;

during the positioning of the solid tubular liner within the wellbore, the resilient standoffs preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

5 radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

the resilient standoffs preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

15 According to another aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

determining that the uncased section traverses a porous subterranean zone; determining that the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone;

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

30 radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

5 Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

10 According to another aspect of the present invention, there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

15 determining that the uncased section traverses a porous subterranean zone;
 determining that the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone;

 if the uncased section is determined to traverse a porous subterranean zone having an operating pressure that is less than the operating pressure of the wellbore, then adding a passive structural means to the solid tubular liner;
20 positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;
 during the positioning of the solid tubular liner within the wellbore, the passive structural means preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone
25 of the uncased section of the wellbore;

 radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

30 the passive structural means preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the

wellbore casing.

Preferably, the expansion device comprises an expansion cone.

Preferably, radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

Brief Description of the Drawings

FIG. 1 is a cross-sectional view illustrating a wellbore including a wellbore casing and an open hole section that traverses a porous subterranean layer.

10 FIG. 2 is a fragmentary cross-sectional view illustrating the introduction of an apparatus for casing the open hole section of the wellbore of FIG. 1.

FIG. 3 is a fragmentary cross-sectional view illustrating the injection of a fluidic material into the apparatus of FIG. 2.

15 FIG. 4 is a fragmentary cross-sectional view illustrating the placement of a plug into the exhaust passage of the shoe of the apparatus of FIG. 3.

FIG. 5 is a fragmentary cross-sectional view illustrating the pressurization of the interior portion of the apparatus below the expansion cone of FIG. 4.

FIG. 6 is a fragmentary cross-sectional view illustrating the completion of the radial expansion of the tubular member of the apparatus of FIG. 5.

20 FIG. 7 is a fragmentary cross-sectional view illustrating the removal of the shoe from the apparatus of FIG. 6.

Detailed Description of the Illustrative Embodiments

An apparatus and method for casing an open hole section of a wellbore within a subterranean formation is provided. The apparatus and method provides
25 a system for casing an open hole section of a wellbore within a subterranean formation in which a tubular member having a plurality of radially oriented standoffs is radially expanded into contact with the preexisting wellbore casing and the open hole section. The standoffs provided on the exterior surface of the tubular member preferably position the tubular member away from the interior
30 walls of the open hole section during the radial expansion process. In this manner, the tubular member does not adhere to underpressurized sections of the open hole

section of the wellbore. In this manner, the process of radial expansion is more reliable.

Referring initially to Fig. 1, a wellbore 100 positioned within a subterranean formation 105 includes a preexisting casing 110 and an open hole section 115 that traverses an porous region 120. When the operating pressure within the wellbore P_{BORE} is greater than the operating pressure within the porous region P_{PORE} , fluidic materials will flow from the wellbore 100 into the porous region 120. As a result of the flow of fluidic materials from the wellbore 100 into the porous region 120, downhole equipment will tend to adhere to, or at least be drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. This can have serious and adverse consequences when radially expanding a tubular member in such an operating environment.

Referring to Fig. 2, an apparatus 200 for forming a wellbore casing in the open hole section of the wellbore 100 may then be positioned within the wellbore in an overlapping relationship with the lower portion of the preexisting wellbore casing 110.

The apparatus 200 includes a tubular support member 205 having a longitudinal passage 210 and a transverse passage 215 that is coupled to an expansion cone 220 having a longitudinal passage 225 that is fluidically coupled to the longitudinal passage 210. The expansion cone 220 is at least partially received within an expansion cone launcher 230 that includes a thin-walled annular member 235 and a shoe 240 having an exhaust passage 245. An expandable tubular member 250 extends from the expansion cone launcher 230 that includes a sealing member 255 and a plurality of standoffs 260a-260h affixed to the exterior surface of the expandable tubular member. In a preferred embodiment, the standoffs 260 are fabricated from a resilient material. A sealing cup 265 is attached to the exterior surface of the tubular support member 205 for preventing foreign materials from entering the interior of the expandable tubular member 250.

In a preferred embodiment, the apparatus 200 is provided as disclosed in one or more of the following: (1) U.S. patent 6,328,113 issued December 11, 2001, and filed as application serial no. 09/440,338, attorney docket number 25791.9.02, filed on 11/15/1999, which claimed benefit of the filing date of U.S.

21 04

provisional patent application serial number 60/108,558, attorney docket number 25791.9, filed on 11/16/1998, (2) U.S. patent 6,497,289, issued December 24, 2002, and filed as application serial no. 09/454,139, attorney docket number 25791.3.02, filed on 12/3/1999, which claimed benefit of the filing date of U.S.

5 provisional patent application serial number 60/111,293, filed on 12/7/1998, (3) U.S. patent application serial number 09/502,350, attorney docket number 25791.8.02, filed on 2/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/119,611, attorney docket number 25791.8, filed on 2/11/1999, (4) U.S. patent application serial number

10 09/510,913, attorney docket number 25791.7.02, filed on 2/23/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,702, attorney docket number 25791.7, filed on 2/25/1999, (5) U.S. patent 6,575,240 issued June 10, 2003, and filed as application serial number 09/511,941, attorney docket number 25791.16.02, filed on 2/24/2000, which

15 claimed the benefit of the filing date of U.S. provisional patent application number 60/121,907, attorney docket number 25791.16, filed on 2/26/1999, (6) U.S. patent application serial number 09/523,460, attorney docket number 25791.11.02, filed on 3/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/124,042, attorney docket number 25791.11,

20 filed on 3/11/1999, (7) U.S. patent 6,604,763, issued August 12, 2003, and filed as application serial number 09/559,122, attorney docket number 25791.23.02, filed on 4/26/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/131,106, attorney docket number 25791.23, filed on 4/26/1999, (8) U.S. patent 6,557,640, issued May 6, 2003, and filed as

25 application serial number 09/588,946, attorney docket number 25791.17.02, filed on June 7, 2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/137,998, attorney docket number 25791.17, filed on 6/7/1999, (9) U.S. provisional patent application serial number 60/143,039, attorney docket number 25791.26, filed on 7/9/1999, (10) U.S.

30 provisional patent application serial number 60/146,203, attorney docket number 25791.25, filed on 7/29/1999; (11) U.S. provisional patent application serial number 60/183,546, attorney docket number 25791.10, filed on 2/18/2000; (12)

- U.S. patent 6,568,471 issued May 27, 2003, and filed as application serial number 09/512,895, attorney docket number 25791.12.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,841, attorney docket number 25791.12, filed on 2/26/1999; (13)
- 5 U.S. provisional patent application serial number 60/212,359, attorney docket number 25791.38, filed on 6/19/2000; (14) U.S. provisional patent application serial number 60/162,671, attorney docket number 25791.27, filed on 11/1/1999; (15) U.S. provisional patent application serial number 60/159,039, attorney docket number 25791.36, filed on 10/12/1999; (16) U.S. provisional patent application
- 10 serial number 60/159,033, attorney docket number 25791.37, filed on 10/12/1999; and (17) U.S. provisional patent application serial number 60/165,228, attorney docket number 25791.39, filed on 11/12/1999.

- As illustrated in Fig. 2, during placement of the apparatus 200 within the wellbore 100, fluidic materials displaced by the apparatus 200 are conveyed
- 15 through the longitudinal passages 210 and 225 to the transverse passage 215. In this manner, surge pressures during the placement of the apparatus 200 within the wellbore 100 are minimized. Furthermore, as illustrated in Fig. 2, the apparatus 200 is preferably initially positioned with upper portion of the tubular member 250 in opposing relation to the lower portion of the preexisting wellbore casing 110.
- 20 In this manner, the upper portion of the tubular member 250 may be radially expanded into contact with the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the placement of the apparatus 200 within the wellbore 100, the standoffs 260a-260h prevent the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the
- 25 vicinity of the porous region 120. In this manner, the apparatus 200 is approximately centered within the wellbore 100.

- As illustrated in Fig. 3, the transverse passage 215 may then be closed and fluidic materials injected into the apparatus 200 through the longitudinal passage 210. In this manner, any blockages within any of the passages 210, 225, and 245
- 30 may be detected by monitoring the operating pressure whereby an increase in operating pressure above nominal, or predetermined, conditions may indicate a blockage of one of the passages.

As illustrated in Fig. 4, a plug 270 or other conventional stop member may then be introduced into the fluidic materials injected into the apparatus 200 through the passage 210, and the plug 270 may be positioned within the exhaust passage 245. In this manner, the exhaust passage 245 may be sealed off. Thus, continued injection of fluidic materials into the apparatus 200 through the passage 210 may thereby pressurize a region 275 below the expansion cone 220.

As illustrated in Figs. 5 and 6, continued pressurization of the region 275 causes the expansion cone 220 to radially expand the expandable tubular member 250 off of the expansion cone. In this manner, the upper portion of the radially expanded tubular member 250 is coupled to the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the radial expansion process, the tubular support member 205 is raised out of the wellbore 100.

In a preferred embodiment, throughout the radial expansion process, the standoffs 260a-260h prevent the exterior surface of the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. In this manner, the apparatus 200 is preferably substantially centered within the wellbore 100. Furthermore, in this manner, the longitudinal center axis of the expansion cone 220 is preferably maintained in a position that is substantially coincident with the longitudinal center axis of the tubular member 250. In addition, in this manner, the stresses applied to the interior surface of the tubular member 250 by the axial displacement of the expansion cone 220 are substantially even. Finally, in this manner, overstressing of the tubular member 250 is prevented thereby eliminating catastrophic failure of the tubular member 250.

As illustrated in Fig. 7, the shoe 240 may then be removed using a conventional milling device.

In a preferred embodiment, upon radially expanding the expandable tubular member 250, the standoffs 260a-260h seal and isolate intervals within the open hole section 115. In several alternative embodiments, the standoffs 260 may be provided, for example, by annular members spaced along the length of the expandable tubular member 250 and/or a continuous member that is wrapped around the expandable tubular member 250 in helical fashion.

21 05 04

It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the apparatus 200 may be used to form and/or repair, for example, a wellbore casing, a pipeline, or a structural support.

5 Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and
10 in a manner consistent with the scope of the invention.

Claims

1. In a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, preventing a portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

2. The method of claim 1, further comprising:

during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore; and

preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

3. The method of claim 1, wherein the expansion device comprises an

expansion cone.

4. The method of claim 1, wherein radially expanding the solid tubular
liner comprises injecting fluidic material into the tubular liner under the expansion
5 device, to displace the expansion device upwards.

5. In a wellbore that traverses a subterranean formation, the wellbore
including a cased section having a wellbore casing and an uncased section that
traverses a porous subterranean zone, wherein the operating pressure of the
10 wellbore is greater than the operating pressure of the porous subterranean zone, a
method of coupling a tubular liner to the wellbore casing of the cased section of
the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the
wellbore with the solid tubular liner overlapping the wellbore casing;
15 during the positioning of the portion of the solid tubular liner that does not
overlap with the wellbore casing within the wellbore proximate the porous
subterranean zone, maintaining the longitudinal center line of the expansion
device in a position that is substantially coincident with the longitudinal center
line of the portion of the solid tubular liner that does not overlap with the wellbore
20 casing;

radially expanding the solid tubular liner by injecting a fluidic material into
the tubular liner to pressurize the interior of the solid tubular liner and displace the
expansion device relative to the solid tubular liner; and

maintaining the longitudinal center line of the expansion device in a
25 position that is substantially coincident with the longitudinal center line of the
portion of the solid tubular liner that does not overlap with the wellbore casing
during the radial expansion of the portion of the solid tubular liner that does not
overlap with the wellbore casing proximate the porous subterranean zone.

30 6. The method of claim 5, wherein the expansion device comprises an
expansion cone.

7. The method of claim 5, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

5 8. The method of claim 5, wherein maintaining the longitudinal centerline of the expansion device during the radial expansion comprises placing a plurality of standoffs about the solid tubular liner.

9. In a wellbore that traverses a subterranean formation and includes a
10 cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

15 means for positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the

20 uncased section of the wellbore;

means for radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

25 means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

10. The system of claim 9, further comprising:

30 means for, during the positioning of the solid tubular liner within the wellbore, preventing the portion of the solid tubular liner that does not overlap

with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

11. The system of claim 9, wherein the expansion device comprises an expansion cone.

12. The system of claim 9, wherein the means for radially expanding the solid tubular liner comprises a means for injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

13. The system of claim 9, wherein the means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone comprises a plurality of standoffs about the solid tubular liner.

14. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

means for positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

means for, during the positioning of the portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore, maintaining the longitudinal center line of the expansion device in a position that is substantially

coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing;

means for radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner

5 and displace the expansion device relative to the solid tubular liner; and

means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner that does not

10 overlap with the wellbore casing.

15 15. The system of claim 14, wherein the expansion device comprises an expansion cone.

16. The system of claim 14, wherein the means for radially expanding the solid tubular liner comprises a means for injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

20 17. The system of claim 14, wherein the means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing during the radial expansion of the portion of the solid tubular liner comprises a plurality of standoffs about the solid
25 tubular liner.

18. An apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous
30 subterranean zone, comprising:

a tubular support member defining a first internal passage;

an expansion device coupled to the tubular support member defining a second internal passage fluidically coupled to the first internal passage;

a tubular expansion device launcher movably coupled to and mating with the expansion device;

5 a solid tubular liner coupled to an end of the tubular expansion device launcher; and

a shoe coupled to another end of the tubular expansion device launcher including a valveable passage;

means for, during a positioning of the solid tubular liner within the
10 wellbore, preventing a portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of
15 the wellbore during a radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

19. The apparatus of claim 18, further comprising:

means for, during the positioning of the solid tubular liner within the
20 wellbore, preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of the wellbore; and

means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from adhering to the porous subterranean zone of
25 the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

20. The apparatus of claim 18, wherein the expansion device comprises an expansion cone.

30

21. The apparatus of claim 18, wherein the means for preventing the portion of the solid tubular liner that does not overlap with the wellbore casing

from contacting the porous subterranean zone of the wellbore during a radial expansion of the portion of the solid tubular liner comprises a plurality of standoffs about the solid tubular liner.

5 22. An apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

 a tubular support member defining a first internal passage;
10 an expansion device coupled to the tubular support member defining a second internal passage fluidically coupled to the first internal passage;
 a tubular expansion device launcher movably coupled to and mating with the expansion device;
 a tubular liner coupled to an end of the tubular expansion device launcher;
15 a shoe coupled to another end of the tubular expansion device launcher including a valveable passage;

 means for, during a positioning of a portion of the solid tubular liner that does not overlap with the wellbore casing within the wellbore, maintaining a longitudinal center line of the expansion device in a position that is substantially
20 coincident with a longitudinal center line of the portion of the solid tubular liner that does not overlap with the wellbore casing; and

 means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the solid tubular liner during a longitudinal displacement of the expansion device
25 relative to the tubular liner.

 23. The apparatus of claim 22, wherein the expansion device comprises an expansion cone.

30 24. The apparatus of claim 22, wherein the means for maintaining the longitudinal center line of the expansion device in a position that is substantially coincident with the longitudinal center line of the solid tubular liner during a

longitudinal displacement of the expansion device comprises a plurality of standoffs about the solid tubular liner.

25. In a wellbore that traverses a subterranean formation and includes a
5 cased section having a wellbore casing and an uncased section that traverses a
porous subterranean zone, wherein the operating pressure of the wellbore is
greater than the operating pressure of the porous subterranean zone, a method of
coupling a tubular liner to the wellbore casing of the cased section of the wellbore,
comprising:
- 10 positioning a solid tubular liner and an expansion device within the
wellbore with the solid tubular liner overlapping the wellbore casing, wherein the
solid tubular liner includes a resilient helical standoff coupled to the exterior
surface of the solid tubular liner;
- during the positioning of the solid tubular liner within the wellbore, the
15 resilient helical standoff preventing the portion of the solid tubular liner that does
not overlap with the wellbore casing from contacting the porous subterranean zone
of the uncased section of the wellbore;
- radially expanding the solid tubular liner by injecting a fluidic material into
the tubular liner to pressurize the interior of the solid tubular liner and displace the
20 expansion device relative to the solid tubular liner;
- and the resilient helical standoff preventing the portion of the solid tubular
liner that does not overlap with the wellbore casing from contacting the porous
subterranean zone of the uncased section of the wellbore during the radial
expansion of the portion of the solid tubular liner that does not overlap with the
25 wellbore casing.

26. The method of claim 25, wherein the expansion device comprises
an expansion cone.

- 30 27. The method of claim 25, wherein radially expanding the solid
tubular liner comprises injecting fluidic material into the tubular liner under the
expansion device, to displace the expansion device upwards.

28. In a wellbore that traverses a subterranean formation and includes a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing, wherein the solid tubular liner includes a plurality of spaced apart resilient standoffs coupled to the exterior surface of the solid tubular liner between the opposite ends of the solid tubular liner;

during the positioning of the solid tubular liner within the wellbore, the resilient standoffs preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

the resilient standoffs preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

29. The method of claim 28, wherein the expansion device comprises an expansion cone.

30. The method of claim 28, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

31. In a wellbore that traverses a subterranean formation, the wellbore

including a cased section having a wellbore casing and an uncased section, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

- 5 determining that the uncased section traverses a porous subterranean zone;
- determining that the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone;
- positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;
- during the positioning of the solid tubular liner within the wellbore,
- 10 preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;
- radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the
- 15 expansion device relative to the solid tubular liner; and
- preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

20

32. The method of claim 31, wherein the expansion device comprises an expansion cone.

- 25 33. The method of claim 31, wherein radially expanding the solid tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

- 30 34. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

determining that the uncased section traverses a porous subterranean zone;

determining that the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone;

if the uncased section is determined to traverse a porous subterranean zone having an operating pressure that is less than the operating pressure of the

5 wellbore, then adding a passive structural means to the solid tubular liner;

positioning a solid tubular liner and an expansion device within the wellbore with the solid tubular liner overlapping the wellbore casing;

during the positioning of the solid tubular liner within the wellbore, the passive structural means preventing the portion of the solid tubular liner that does
10 not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion device relative to the solid tubular liner; and

15 the passive structural means preventing the portion of the solid tubular liner that does not overlap with the wellbore casing from contacting the porous subterranean zone of the uncased section of the wellbore during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing.

20

35. The method of claim 34, wherein the expansion device comprises an expansion cone.

36. The method of claim 34, wherein radially expanding the solid
25 tubular liner comprises injecting fluidic material into the tubular liner under the expansion device, to displace the expansion device upwards.

37. A method of coupling a tubular liner to a wellbore casing substantially as described herein.

30

38. A system for coupling a tubular liner to a wellbore casing substantially as described herein with reference to and as illustrated in Figures 2 to

21 45 04

7 of the accompanying drawings.

39. An apparatus for coupling a tubular liner to a wellbore casing
substantially as described herein with reference to and as illustrated in Figures 2 to
5 7 of the accompanying drawings.